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APPLICATION FOR LETTERS PATENT

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**Thin Profile Battery Bonding Method, Method Of
Conductively Interconnecting Electronic Components,
Battery Powerable Apparatus, Radio Frequency
Communication Device, And Electric Circuit**

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INVENTOR

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1 Thin Profile Battery Bonding Method, Method Of Conductively
2 Interconnecting Electronic Components, Battery Powerable Apparatus,
3 Radio Frequency Communication Device, And Electric Circuit

5 TECHNICAL FIELD

6 This invention relates to thin profile battery bonding methods, to
7 methods of conductively interconnecting electronic components, to battery
8 powerable apparatus, to radio frequency communication devices, and to
9 electric circuits.

10 BACKGROUND OF THE INVENTION

11 Thin profile batteries comprise batteries that have thickness
12 dimensions which are less than a maximum linear dimension of its
13 anode or cathode. One type of thin profile battery is a button type
14 battery. Such batteries, because of their compact size, permit electronic
15 devices to be built which are very small or compact.

16 One mechanism by which thin profile batteries are electrically
17 connected with other circuits or components is with electrically
18 conductive adhesive, such as epoxy. Yet in some applications, a suitably
19 conductive bond or interconnection is not created in spite of the highly
20 conductive nature of the conductive epoxy, the outer battery surface,
21 and the substrate surface to which the battery is being connected. This
22 invention arose out of concerns associated with providing improved
23 conductive adhesive interconnections between thin profile batteries and

1 conductive nodes formed on substrate surfaces. The invention has other
2 applicability as will be appreciated by the artisan, with the invention
3 only being limited by the accompanying claims appropriately interpreted
4 in accordance with the Doctrine of Equivalents.

5

6 **SUMMARY OF THE INVENTION**

7 The invention in one aspect includes a thin profile battery
8 bonding method. In one implementation, a curable adhesive composition
9 is provided which comprises an epoxy terminated silane. A thin profile
10 battery and a substrate to which the thin profile battery is to be
11 conductively connected are also provided. The curable adhesive
12 composition is interposed between the thin profile battery and the
13 substrate. It is cured into an electrically conductive bond electrically
14 interconnecting the battery and the substrate.

15 The invention in another aspect includes a method of conductively
16 interconnecting electronic components. In one implementation, a curable
17 adhesive composition comprising an epoxy terminated silane is provided.
18 First and second electronic components to be conductively connected
19 with one another are provided. The curable adhesive composition is
20 interposed between the first and second electronic components. The
21 adhesive is cured into an electrically conductive bond electrically
22 interconnecting the first and second components.

23 The invention in still another aspect includes interposing a curable
24 epoxy composition between first and second electrically conductive

1 components to be electrically interconnected. At least one of the
2 components comprises a metal surface with which the curable epoxy is
3 to electrically connect. The epoxy is cured into an electrically
4 conductive bond electrically interconnecting the first and second
5 components. The epoxy has an effective metal surface wetting
6 concentration of silane to form a cured electrical interconnection having
7 a contact resistance through said metal surface of less than or equal to
8 about 0.3 ohm-cm².

9 The invention in a further aspect includes a battery powerable
10 apparatus. In one implementation, such includes a substrate having a
11 surface comprising at least one node location. A thin profile battery
12 is mounted over the substrate and node location. A conductive
13 adhesive mass electrically interconnects the thin profile battery with the
14 node location, with the conductive adhesive mass comprising an epoxy
15 terminated silane.

16 The invention in still a further aspect includes a radio frequency
17 communication device. In one implementation, such includes a substrate
18 having conductive paths including an antenna. At least one integrated
19 circuit chip is mounted to the substrate and in electrical connection with
20 a first portion of the substrate conductive paths. A thin profile battery
21 is conductively bonded with a second portion of the substrate conductive
22 paths by a conductive adhesive mass, with the conductive adhesive mass
23 comprising an epoxy terminated silane.

1 The invention in still another aspect includes an electric circuit
2 comprising first and second electric components electrically connected
3 with one another through a conductive adhesive mass comprising an
4 epoxy terminated silane.

5

6 **BRIEF DESCRIPTION OF THE DRAWINGS**

7

8 Preferred embodiments of the invention are described below with
9 reference to the following accompanying drawings.

10 Fig. 1 is a side elevational, partial cross sectional, view of a thin
11 profile battery.

12 Fig. 2 is a side elevational view of a substrate.

13 Fig. 3 is a side elevational view of a battery powerable apparatus.

14 Fig. 4 is a diagrammatic plan view of a radio frequency
15 communication device.

16 **DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS**

17 This disclosure of the invention is submitted in furtherance of the
18 constitutional purposes of the U.S. Patent Laws "to promote the
19 progress of science and useful arts" (Article 1, Section 8).

20 Referring to Fig. 1, a single thin-profile battery is indicated
21 generally with reference numeral 10. In the context of this document,
22 "thin-profile battery" is intended to define any battery having a thickness
23 dimension which is less than a maximum linear dimension of its anode
24 or cathode. The preferred and illustrated battery 10 comprises a

1 circular button-type battery. Such comprises a lid terminal housing
2 member 14 and a can terminal housing member 12. Can 12 is crimped
3 about lid 14, having an insulative sealing gasket 16 interposed
4 therebetween. In the illustrated example, gasket 16 projects outwardly
5 slightly relative to the crimp as shown.

6 Fig. 2 illustrates a substrate 22 to which thin-profile battery 10
7 is to be conductively connected. Substrate 22 includes an outer
8 surface 23 having one node location 24 and another node location 25
9 to which battery electrical connection is desired. Substrate 22, for
10 example, can comprise a flexible circuit substrate, wherein nodes 24
11 and 25 comprise printed thick film ink formed on surface 23.

12 Referring to Fig. 3, a curable adhesive composition or mass 26
13 comprising an epoxy-terminated silane is interposed between lid 14 of
14 thin profile battery 10 and substrate 22 over node location 25. Further,
15 a curable adhesive composition or mass 32 comprising an
16 epoxy-terminated silane is interposed between can 12 of thin-profile
17 battery 10 and node location 24 on substrate 22. The preferred
18 curable adhesive composition comprises a two-part epoxy resin and
19 hardener system, wherein the preferred epoxy-terminated silane comprises
20 a glycidoxy methoxy silane, such as a glycidoxypropyltrimethoxysilane,
21 with 3-glycidoxypropyltrimethoxysilane being a specific example. The
22 epoxy-terminated silane is preferably present in the curable adhesive
23 composition at less than or equal to about 2% by weight, with less
24 than or equal to about 1% by weight being even more preferred.

1 One example 3-glycidoxypolytrimethoxysilane is available from
2 Dow Corning Corporation of Midland, Michigan, as Z-6040TM Silane.
3 An example resin and hardener system for a conductive epoxy is
4 available from Creative Materials, Inc., of Tyngsboro, MA, as Part
5 Nos. CMI 116-37ATM and CMIB-187TM, respectively. In a preferred
6 example, from 0.5 to 2.0 weight parts of Z-6040TM silane is combined
7 with 100 weight parts of the CMI 116-37ATM silver epoxy resin. A
8 preferred concentration of the Z-6040TM is 1 weight part with 100
9 weight parts of epoxy resin. Such a solution is thoroughly mixed and
10 combined with, for example, 3 weight parts of the CMIB-187TM
11 hardener, with the resultant mixture being further suitably mixed to form
12 composition 26.

13 The composition is applied to one or both of battery 10 or
14 substrate 22, and provided as shown in Fig. 3. An example size for
15 conductive mass 26 is a substantially circular dot having a diameter of
16 about 0.080 inch (0.2032 cm) and a thickness of about 0.002 inch
17 (0.00508 cm). Resistance of a fully cured mass 26 was measured with
18 an ohmmeter from the top of the mass to the substrate surface, which
19 comprised a nickel-clad stainless steel Eveready CR2016TM button-type
20 battery can. Typical measured resistance where no epoxy-terminated
21 silane or other additive was utilized ranged from 10 ohms to 100 ohms,
22 with in some instances resistance being as high as 1000 ohms. These
23 correspond to respective calculated contact resistances ranging from
24 about 0.32 ohm-cm² to 3.24 ohms-cm², with as high as 32.43 ohms-cm²,

1 when ignoring the volume resistances of the epoxy mass and substrate.
2 At the time of preparation of this document, 10 ohms (and its
3 associated calculated contact resistance of 0.32 ohm-cm^2) is considered
4 high and unacceptable for purposes and applications of the assignee,
5 such as will be described with reference to Fig. 4. Yet where the
6 epoxy-terminated silane was added, for example at a weight percent of
7 2% or less, the typical resistance value and range dropped significantly
8 to 0.1 ohm to 1.0 ohm, with 0.2 ohm being typical. These correspond
9 to respective contact resistances of about 0.0032 ohm-cm^2 , 0.032
10 ohm-cm^2 , and 0.0064 ohm-cm^2 .

11 It is perceived that the prior art conductive bonding without the
12 epoxy-terminated silane results from poor wetting characteristics of the
13 conductive epoxy with the metal outer surface of the button-type
14 battery, which typically comprises a nickel-clad stainless steel. The
15 epoxy-terminated silane significantly improves the wetting characteristics
16 relative to the metal surfaces, such as nickel-clad stainless steel, in a
17 conductive epoxy system in a manner which is not understood to have
18 been reported or known in the prior art. Accordingly in accordance
19 with another aspect of the invention, a thin-profile battery bonding
20 method interposes epoxy between a battery and substrate with at least
21 one of such having a metal surface to which the curable epoxy is to
22 electrically connect. The epoxy has an effective metal surface wetting
23 concentration of silane to form a cured electrical interconnection having
24 a contact resistance through said metal surface of less than or equal to

1 about 0.30 ohm-cm². More preferred, the epoxy has an effective metal
2 surface wetting concentration of silane to form a cured electrical
3 interconnection have a contact resistance through said metal surface of
4 less than or equal to about 0.16 ohm-cm². Most preferred, such
5 concentration provides a contact resistance of less than or equal to
6 about 0.032 ohm-cm².

7 The curable adhesive composition is then cured into an electrically
8 conductive bond which electrically interconnects the battery and substrate
9 as shown in Fig. 3. In the preferred embodiment, such electrically
10 conductive bond also is the sole physical support and connection of the
11 battery and its terminals relative to substrate 22.

12 Although the invention was reduced to practice utilizing formation
13 of a conductive interconnection between a metal battery terminal and
14 a printed thick film on a substrate, the invention has applicability in
15 methods and constructions of producing an electric circuit comprising
16 other first and second electric components which electrically connect with
17 one another through a conductive adhesive mass comprising, in a
18 preferred embodiment, an epoxy-terminated silane.

19 Fig. 3 depicts an exemplary battery powerable apparatus and
20 electric circuit 30 in accordance with an aspect of the invention. In
21 one preferred implementation, battery powerable apparatus 30 preferably
22 comprises a radio frequency communication device 50 as exemplified in
23 Fig. 4. In such example, substrate 22 preferably comprises a flexible
24 circuit substrate, with nodes 25 and 24 constituting a portion of a series

1 of conductive paths formed of printed thick film ink on surface 23 of
2 flexible substrate 22. Such conductive paths includes antenna
3 portions 54. At least one, and preferably only one, integrated circuit
4 chip 52 is mounted relative to substrate 22 and in electrical connection
5 with a first portion of the substrate conductive paths. Mounting is
6 preferably with electrically conductive epoxy such as described above.
7 Adhesive mass 26 electrically connects lid 14 of thin profile battery 10
8 with a second portion of the substrate conductive paths. In this
9 example, such second portion comprises a series of printed thick film
10 nodes 25. Conductive adhesive mass 32 electrically connects with a
11 third portion of the substrate conductive paths, which in this example
12 comprises node 24 in the shape of an arc.

13 An exemplary single integrated circuit chip is described in U.S.
14 Patent Application Serial No. 08/705,043, which names James O'Toole,
15 John R. Tuttle, Mark E. Tuttle, Tyler Lowery, Kevin Devereaux, George
16 Pax, Brian Higgins, Shu-Sun Yu, David Ovard, and Robert Rotzoll as
17 inventors, which was filed on August 29, 1996, and is assigned to the
18 assignee of this patent application. The entire assembly 50 preferably
19 is encapsulated in and comprises an insulative epoxy encapsulant
20 material. Example constructions and methods for providing the same
21 are described in a) U.S. Patent Application entitled "Battery Mounting
22 Apparatuses, Electronic Devices, And Methods Of Forming Electrical
23 Connections", which names Ross S. Dando, Rickie C. Lake, and Krishna
24 Kumar as inventors, and was filed on _____, and

1 b) U.S. Patent Application entitled "Battery Mounting And Testing
2 Apparatuses, Methods Of Forming Battery Mounting And Testing
3 Apparatuses, Battery-Powered Test-Configured Electronic Devices, And
4 Methods Of Forming Battery-Powered Test-Configured Electronic
5 Devices", which names Scott T. Trosper as inventor, and which was filed
6 on _____, both of which are assigned to the
7 assignee of this patent application. Each of the above three referenced
8 patent applications is fully incorporated herein by reference. Although
9 this disclosure shows a single battery 10 mounted to substrate 22 for
10 clarity and ease of description, multiple button type batteries stacked in
11 series are preferably utilized as is collectively disclosed in the
12 incorporated disclosures.

13 In compliance with the statute, the invention has been described
14 in language more or less specific as to structural and methodical
15 features. It is to be understood, however, that the invention is not
16 limited to the specific features shown and described, since the means
17 herein disclosed comprise preferred forms of putting the invention into
18 effect. The invention is, therefore, claimed in any of its forms or
19 modifications within the proper scope of the appended claims
20 appropriately interpreted in accordance with the doctrine of equivalents.